CLAIMS

1. A method of using an optical fibre to obtain a distributed measurement of a parameter of interest, comprising:

deploying an optical fibre in a measurement region of interest;

launching a first optical signal at a first wavelength λ_0 and a first optical power level into the optical fibre;

detecting backscattered light emitted from the optical fibre at a second wavelength λ_{-1} arising from inelastic scattering of the first optical signal, and generating a first output signal therefrom, the first output signal being indicative of the parameter of interest;

detecting backscattered light emitted from the optical fibre at the first wavelength λ_0 arising from elastic scattering of the first optical signal, and generating a second output signal therefrom;

launching a second optical signal at the second wavelength λ_{-1} into the optical fibre;

detecting backscattered light emitted from the optical fibre at the second wavelength λ_{-1} arising from elastic scattering of the second optical signal, and generating a third output signal therefrom;

launching a third optical signal at the first wavelength λ_0 and a second optical power level less than the first optical power level into the optical fibre;

detecting backscattered light emitted from the optical fibre at the first wavelength λ_0 arising from elastic scattering of the third optical signal, and generating a fourth output signal therefrom;

generating a synthetic output signal from the second output signal and the fourth output signal; and

generating a final output signal indicative of the parameter of interest by normalising the first output signal to the geometric mean of the synthetic output signal and the third output signal.

2. A method according to claim 1, in which the second optical power level is selected to be below a threshold for nonlinear optical interactions of light at the first wavelength λ_0 propagating in the optical fibre.

3. A method according to claim 1 or claim 2, in which the synthetic output signal is generated by normalising the square of the second output signal to the fourth output signal.

4. A method according to any preceding claim, in which the inelastic scattering is Raman scattering and the second wavelength λ_{-1} is an anti-Stokes band of the first wavelength λ_0.

5. A method according to claim 4, in which the parameter of interest is temperature.

6. A method according to any preceding claim, and further comprising matching spectral features of the inelastically backscattered light at the second wavelength λ_{-1} to spectral features of the second optical signal.

7. A method according to claim 6, in which the inelastically backscattered light at the second wavelength λ_{-1} is spectrally filtered before the first output signal is generated.

8. A method according to claim 6 or claim 7, in which the second optical signal is spectrally broadened before it is launched into the optical fibre.

9. A method according to any preceding claim, in which the method further comprises passing the backscattered light emitted from the optical fibre through a mode filter to remove higher order modes.

10. A method according to claim 9, in which the optical fibre has a first core diameter and a first numerical aperture, and the mode filter comprises an optical fibre having a second core diameter smaller than the first core diameter and a second numerical aperture smaller than the first numerical aperture.

11. A method according to claim 9, in which the mode filter comprises a spatial filter arranged to attenuate the higher order modes.

12. A method according to any preceding claim, in which the optical fibre has a core region comprising silica doped with germanium.

13. A method according to claim 12, in which the optical fibre has a core region comprising silica doped only with germanium.

14. A method according to any preceding claim, in which the optical fibre is deployed within a well bore of an oil well.

15. A method according to any preceding claim, and further comprising generating one or both of the first optical signal and the third optical signal by taking an optical signal at the second wavelength λ_{-1} from an optical source operable to generate the second optical signal, and passing the optical signal at the second wavelength λ_{-1} through a Raman shifting optical fibre so as to generate light at the first wavelength λ_0 by the process of stimulated Raman scattering within the Raman shifting optical fibre.

16. Apparatus for obtaining a distributed measurement of a parameter of interest, comprising:

an optical fibre for deployment in a measurement region of interest;

one or more optical sources operable to generate and launch into the optical fibre:

a first optical signal at a first wavelength λ_0 and a first optical power level;

a second optical signal at a second wavelength λ_{-1}; and

a third optical signal at the first wavelength λ_0 and a second optical power level less than the first optical power level; and

one or more detectors operable to:

detect backscattered light emitted from the optical fibre at the second wavelength λ_{-1} arising from inelastic scattering of the first optical signal, and to generate a first output signal therefrom, the first output signal being indicative of the parameter of interest;

detect backscattered light emitted from the optical fibre at the first wavelength λ_0 arising from elastic scattering of the first optical signal, and to generate a second output signal therefrom;

detect backscattered light emitted from the optical fibre at the second wavelength λ_{-1} arising from elastic scattering of the second optical signal, and to generate a third output signal therefrom; and

detect backscattered light emitted from the optical fibre at the first wavelength λ_0 arising from elastic scattering of the third optical signal, and to generate a fourth output signal therefrom; and

a signal processor operable to generate a synthetic output signal from the second output signal and the fourth output signal and to generate a final output signal indicative of the parameter of interest by normalising the first output signal to the geometric mean of the synthetic output signal and the third output signal.

17. Apparatus according to claim 16, in which the one or more optical sources comprises a single optical source operable to generate the first optical signal and the third optical signal, the single optical source comprising a power control operable to alter the optical power level of an optical signal generated by the single optical source between the first optical power level and the second optical power level.

18. Apparatus according to claim 16 or claim 17, in which the one or more optical sources comprises an optical source operable to generate the second optical signal, and one or more Raman shifting optical fibres arranged to receive an optical signal at the second wavelength λ_{-1} from the optical source operable to generate the second optical signal and to generate the first optical signal and the third optical signal by the process of stimulated Raman scattering within the Raman shifting optical fibre.

19. Apparatus according to any one of claims 16 to 18, in which the second optical power level is selected to be below a threshold for nonlinear optical interactions of light at the first wavelength λ_0 propagating in the optical fibre.

20. Apparatus according to any one of claims 16 to 19, in which the processor is operable to generate the synthetic output signal by normalising the square of the second output signal to the fourth output signal.

21. Apparatus according to any one of claims 16 to 20, in which the inelastic scattering is Raman scattering and the second wavelength λ_{-1} is an anti-Stokes band of the first wavelength λ_0.

22. Apparatus according to claim 21, in which the parameter of interest is temperature.

23. Apparatus according to any one of claims 16 to 22, and further comprising a spectral modifier operable to match spectral features of the inelastically backscattered light at the second wavelength λ_{-1} to spectral features of the second optical signal.

24. Apparatus according to claim 23, in which the spectral modifier comprises one or more spectral filters through which the inelastically scattered light at the second wavelength λ_{-1} is passed before the first output signal is generated.

25. Apparatus according to claim 23 or claim 24, in which the spectral modifier comprises a spectral broadening arrangement operable to spectrally broaden the second optical signal before it is launched into the optical fibre.

26. Apparatus according to any one of claims 16 to 25, in which the apparatus further comprises a mode filter operable to remove higher order modes from the backscattered light emitted from the optical fibre.

27. Apparatus according to claim 26, in which the optical fibre has a first core diameter and a first numerical aperture, and the mode filter comprises an optical fibre arranged to receive the backscattered light emitted from the optical fibre and comprising an optical fibre having a second core diameter smaller than the first core diameter and a second numerical aperture smaller than the first numerical aperture.

28. Apparatus according to claim 26, in which the mode filter comprises a spatial filter arranged to attenuate the higher order modes.

29. Apparatus according to any one of claims 16 to 28, in which the optical fibre has a core region comprising silica doped with germanium.

30. Apparatus according to claim 29, in which the optical fibre has a core region comprising silica doped only with germanium.

31. Apparatus according to any one of claims 16 to 30, in which the optical fibre is for deployment within a well bore of an oil well.

32. Apparatus according to claim 31, and further comprising a fibre deployment mechanism operable to deploy the optical fibre into the well bore.

33. Apparatus according to any one of claims 16 to 32, and further comprising a switch switchable between:

a first configuration in which the switch connects the optical fibre to the one or more optical sources so that the first optical signal and the third optical signal are launched into the optical fibre, and to the one or more detectors so that the one or more detectors detect backscattered light arising from inelastic scattering of the first optical signal, backscattered light arising from elastic scattering of the first optical signal, and backscattered light arising from elastic scattering of the third optical signal; and

a second configuration in which the switch connects the optical fibre to the one or more optical sources so that the second optical signal is launched into the optical fibre, and to the one or more detectors so that the one or more detectors detect backscattered light arising from elastic scattering of the second optical signal.

34. A method of using an optical fibre to obtain a distributed measurement of a parameter of interest substantially as described herein with reference to the accompanying drawings.

35. Apparatus for obtaining a distributed measurement of a parameter of interest substantially as described herein with reference to the accompanying drawings.